INDOOR AIR QUALITY REASSESSMENT

North Intermediate School
320 Salem Street
Wilmington, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of parents, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health, Bureau of Environmental Health Assessment (BEHA), provided assistance and consultation regarding indoor air quality at the North Intermediate School (NIS), 320 Salem Street, Wilmington, Massachusetts. The request was prompted by occupant concerns thought to be related to indoor environmental conditions.

On March 11, 2004, Cory Holmes, an Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of this building. Mr. Holmes was accompanied by George Hooper, Assistant Superintendent, Public Buildings Department, Town of Wilmington. The school was previously visited by BEHA staff in January of 1997. A report was issued describing building conditions at that time and also included recommendations to correct problems, (MDPH, 1997).

The NIS is a two-story brick building that was constructed in 1962. A cafeteria was added in the mid to late 1980's. The majority of building components (e.g., floors, ceilings, ventilation equipment) are original.

Actions on Recommendations Previously Made by MDPH

As previously discussed, BEHA staff visited the building in January 1997 and issued a report that provided recommendations to improve indoor air quality (MDPH, 1997). A summary of actions taken on previous recommendations is included as Appendix A of this reassessment.

Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with a TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school houses approximately 350 fourth and fifth grade students and has a staff of approximately 40. The tests were taken during normal operations at the school. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from Tables 1-3 that carbon dioxide levels in the indoor air were elevated above 800 parts per million (ppm) in eleven of twenty-four areas surveyed, indicating inadequate ventilation in a number of areas. Fresh air in classrooms is supplied by a unit ventilator (univent) system (Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 2) and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. All univents were operating during the assessment. Fresh air in classrooms is supplemented by openable windows. In addition, wall mounted fans were installed in each classroom to facilitate airflow (Picture 3). Exhaust ventilation is provided by ducted, grated wall vents (Picture 4), powered by rooftop motors. All exhaust vents were operating during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. Town officials reported that the mechanical ventilation systems had not been balanced since the last BEHA report (MDPH, 1997). It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix B.

Temperature measurements ranged from 69 ^{o} F to 75 ^{o} F, which were very close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 17 to 27 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of areas had water-damaged ceiling tiles which appeared to be the result of historic roof and/or plumbing leaks (Tables 1-3). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. The suspended ceiling design increases the difficulty of replacing ceiling tiles. The system consists of a suspended ceiling of interlocking tiles, which requires the removal of a number of tiles. (Refer to Appendix A for information regarding ceiling tile replacement). This design renders replacement of water-damaged tile difficult.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure.

To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5. Outdoor carbon monoxide concentrations were non-detect or ND (Tables 1-3). Carbon monoxide levels measured in the school were also ND.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. *Carbon monoxide should not be present in a typical, indoor environment.* If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels.

Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions of reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000).

The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA

Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 μg/m^3 over a 24-hour average (US EPA, 2000). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment. Outdoor PM2.5 concentrations (i.e., background levels) were measured at 8 μg/m^3 (Tables 1-3). PM2.5 levels measured indoors ranged from 7 to 18 μg/m^3. Although PM2.5 measurements were above background in some areas, they were below the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detect (ND) (Tables 1-3). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products (e.g., use of product increases the concentration of TVOC within a classroom).

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. The teacher's workroom had several photocopiers. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). To help reduce excess heat and odors in these areas, school personnel should ensure that local exhaust ventilation (Picture 5) is activated while equipment is in use.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and lead to off-gassing of VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix C (NIOSH, 1998).

Other conditions that can affect indoor air quality were noted during the assessment. Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized. Once aerosolized, chalk dust can become irritating to eyes and the respiratory system. Similarly, pencil shavings were observed to be accumulating at the base of pencil sharpeners. In many classrooms, pencil sharpeners are installed on univents or radiators (Picture 6). When radiators or univents are operating, pencil shavings can become airborne, providing a source of eye and respiratory irritation.

Lastly, open utility holes, missing ceiling tiles, and in classroom 208, spaces between the floor and the wall were observed (Pictures 7 and 8). Spaces between the floor and walls may be the result of settling. These breaches can serve as a means for odors, dusts and particulates to migrate between rooms and floors.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue operating both supply and exhaust ventilation continuously during periods of school occupancy to maximize air exchange. Supplement airflow with the use of openable windows and wall-mounted fans.
2. Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).
3. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to

minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).

4. Replace any remaining water-stained ceilings.
5. Seal breaches around utility holes and spaces between walls and floors to prevent the migration of odors, dust and particulate matter between areas.
6. Operate local exhaust vent in teacher's workroom during photocopier use.
7. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.
8. Relocate pencil sharpeners from the air diffusers of univents and radiators.
9. Store cleaning products properly and out of reach of students.
10. Consider discontinuing the use of tennis balls on chair legs.
11. Consider adopting the US EPA document, "Tools for Schools", in order to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
12. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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Picture 1

Classroom Unit Ventilator (Univent) 1960's Vintage

Picture 2

Univent Fresh Air Intake

Picture 3

Wall-Mounted Fan Installed in Classroom

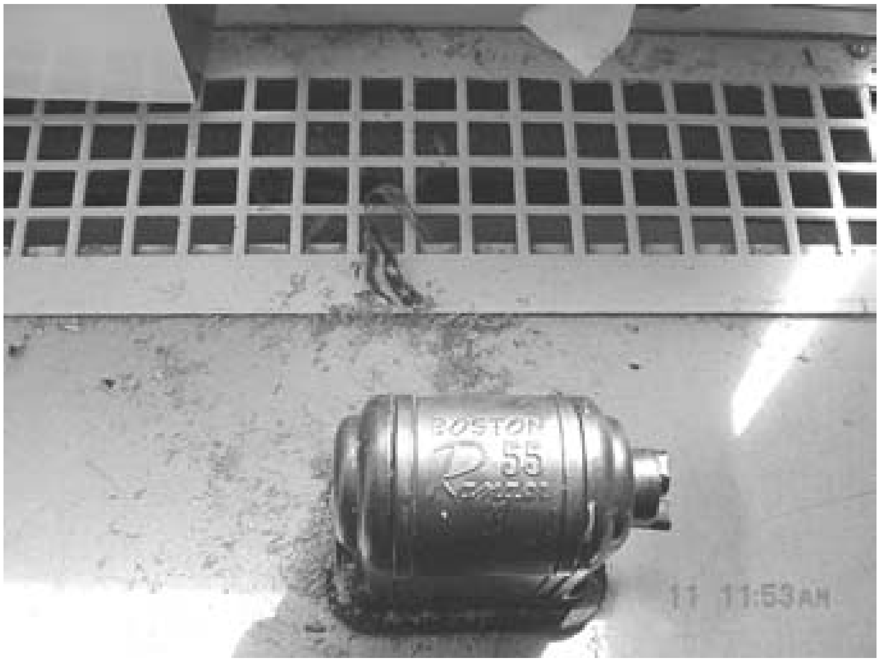
Picture 4

Classroom Exhaust Vent

Picture 5

Local Exhaust Vent in Teacher's Workroom

Picture 6



Pencil Sharpener in Classroom

Picture 7

Open Utility Hole in Classroom

Picture 8

Space Between Wall and Floor in Classroom 208

Building: Wilmington North Intermediate School **Indoor Air Test Results**
Address: Wilmington, MA **Date: 03/11/04**

TABLE 1

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	CO (ppm)	TVOCs (ppm)	PM (µg/m³)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background		36	23	359	ND	ND	8				North winds, 15-20 MPH, Overcast
208	26	71	27	1100	ND	ND	8	Y	Y	Y	2 MT/AT, DEM, TB, Cleaners, Space between wall and floor
207	24	74	21	904	ND	ND	11	Y	Y	Y	DEM, Aquarium/Terrarium
205	22	75	19	746	ND	ND	12	N	Y	Y	
202	24	73	25	1828	ND	ND	11	Y	Y	Y	1 MT/AT, DEM, Supply blocked by furniture
203	25	73	22	1210	ND	ND	12	Y	Y	N	2 MT/AT DEM, PF, Wall mounted AC
200	21	72	21	1029	ND	ND	11	Y	Y	Y	CD, PF, Aquarium/terrarium, Plants
201	24	73	24	1270	ND	ND	14	N	Y	Y	Aquarium/Terrarium, Supply blocked by furniture, 1 MT/AT
105	18	74	20	766	ND	ND	9	Y	N	N	1 MT/AT, DEM, TB, PF, Cleaners, 10 WD-CT

ppm = parts per million parts of air
AT = ajar tile
AD = air deodorizer
AHU = air-handling unit
AP = air purifier
AC = air conditioning
CD = chalk dust
CT= ceiling tile
DEM = dry erase marker
DO = door open
MT= missing ceiling tile
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WD = water damage
ND = non-detect

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	CO (ppm)	TVOCs (ppm)	PM (µg/m³)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
100	1	74	17	528	ND	ND	9	Y	Y	Y	WD-CT from old UV leak, 7 WD-CT
Library	0	74	18	587	ND	ND	9	Y	Y	N	DEM, PF, 3 MT/AT
Cafeteria	~200	73	20	1800	ND	ND	17	Y	Y	Y	PF
Instrumental RM	1	72	17	467	ND	ND	9	N	Y	Y	DEM
Teacher's WK RM										Y	2 PC, Local exhaust off, Reactive
Music Center	3	74	20	794	ND	ND	10	Y	Y	Y	15 WD-CT, 3 MT/AT, DEM
Gym	0	69	18	619	ND	ND	7	Y	Y	Y	
Computer Lab 101	0	73	19	683	ND	ND	12	Y	Y	Y	5 CT visible mold, PF, CT removed for wiring
103	23	72	21	917	ND	ND	15	Y	Y	Y	7 WD-CT, PF, TB, Cleaners, Utility hole

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Relative Humidity -	40 - 60%

Building: Wilmington North Intermediate School | **Indoor Air Test Results**
Address: Wilmington, MA | **Date: 03/11/04**

TABLE 3

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	CO (ppm)	TVOCs (ppm)	PM (µg/m³)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
107	23	72	17	513	ND	ND	10	Y	Y	Y	10 CT visible mold, DEM, PF, Pencil shavings radiator vent, WD CT historic leak
102	0	74	17	487	ND	ND	8	Y	Y	Y	DEM
104	13	73	17	554	ND	ND	8	Y	Y	Y	CD, DEM
109	23	74	21	706	ND	ND	18	Y	Y	Y	DEM, PF
209	4	73	20	818	ND	ND	10	Y	Y	Y	DEM, PF
204	19	74	18	775	ND	ND	9	Y	Y	Y	CD, DEM
206	22	73	24	1652	ND	ND	15	Y	Y	Y	CD, PF, Aquarium/terrarium, 1 MT/AT
211	23	74	23	1032	ND	ND	12	Y	Y	Y	3 MT/AT, DEM, PF, TB, Area rugs, Pillows

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AC = air conditioning
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Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

Appendix A

Actions on MDPH Recommendations, North Intermediate School, Wilmington, MA

The following is a status report of action(s) taken on MDPH recommendations (**in bold**) based on reports from town officials, school maintenance staff, documents, photographs and MDPH, BEHA staff observations.

1. **In order to improve indoor air quality, an increase in the percentage of fresh air supply into the univent system may be necessary. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room.**

   Action: Town officials reported that the univents were surveyed, checked and found in good working order. All univents were operable during the reassessment. In addition original wire mesh filters were replaced with disposable filters.

2. **Evaluate the exhaust system for function and repair. Clear a three-foot space in front of all exhaust vents where feasible.**

   Action: All **e**xhaust vents were operating and free from obstruction during the reassessment.

3. **Once both the fresh air supply and exhaust ventilation are functioning, the ventilation system needs to be balanced.**

   Action: Town officials reported that the mechanical ventilation systems had not been balanced since the last BEHA report (MDPH, 1997). Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

Appendix A

4. **Either remove shrubbery obstruction from univents along the first floor of the front of the building or cut back shrubbery at least two feet away from the outer wall of the building.**

   Action: Shrubbery appeared to be against the building in some areas during the assessment. School officials reported that trimming back shrubbery is an on-going project.

5. **Preventing access to univent controls may be a necessary step to make sure these systems cannot be turned off.**

   Action: Town and school officials reported that staff were given instructions not to deactivate ventilation components and to contact the office or head custodian regarding temperature/ventilation issues.

6. **Preventing the use of the univent as book shelving/storage areas is necessary to have this system function properly. Remove plants and other organic matter from the univents.**

   Action: Univents were free from obstructions and plants had been removed.

7. **Have all complaints concerning problems with heat and ventilation reported to one person to avoid confusion.**

   Action: See Action 5.

8. **Replace all water stained ceiling tiles. Examine the area above these tiles for continuing water leaks and repair. Disinfect areas of water leaks with an appropriate antimicrobial.**

   Action: Town officials reported that leaks have been repaired, all areas above water stained ceiling tiles were examined and a number of water-damaged tiles

Appendix A

have been replaced. BEHA staff however, noted a number of areas where stained ceiling tiles were not replaced (Table 1).

9. **Repair exhaust fan in cafeteria.**

   Action: The exhaust fan in the cafeteria was repaired and operating during the reassessment.

10. **Prevent water from penetration through to the outside door of the art room.**

    Action: Water penetration through the exterior door in the former art room has been eliminated; the area is now used for storage.

11. **The maintenance staff should refrain from using hazardous materials/odorous chemicals with students present in an area or during school hours.**

    Action: This practice has been eliminated.